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(71) Applicant: TYCO ELECTRONICS CORPORATION [US/US]; 2901 Fulling Mill Road, Middletown, PA 17057-3163 (US).

(72) Inventors: MARTENS, Paul, W.; 1924 Rheem Drive, Pleasanton, CA 94565 (US). MEHAN, Ashok; 30760 Tidewater Drive, Union City, CA 94587 (US). RODKEY, Richard; 2620 Camino Segura, Pleasanton, CA 94566 (US).

(74) Agent: NOVACK, Sheri, M.; Tyco Electronics Corporation, Intellectual Property Law Dept., 300 Constitution Drive, MS 106/1B, Menlo Park, CA 94025-1164 (US).

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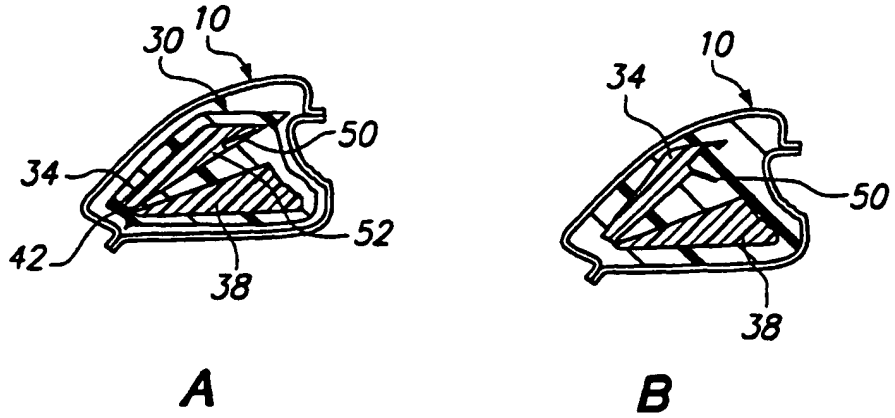
(54) Title: CAVITY SEALING ARTICLE WITH ARTICULATED SUPPORT



(57) Abstract: A planar cavity sealing article comprises : (a) a planar articulated support (38), and (b) a sealer (30) comprising an uncrosslinked foamable polymer in intimate contact with the articulated support and surrounding the articulated support in the plane of the articulated support.

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CAVITY SEALING ARTICLE WITH ARTICULATED SUPPORT

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

This invention relates to sealing articles for cavities, and methods for making and using them. More particularly, this invention relates to sealing articles for channels in automobiles or other land vehicles, boats or other marine vehicles, aircraft or other aerospace vehicles, structures, including land and marine structures, and the like, wherever it is desirable to seal a cavity against the passage of air, moisture, fluids, particulates, and the like. In a particular aspect, this invention relates to the sealing of channels, such as pillars, in the body structure of automobiles and similar vehicles; and the invention will be discussed primarily with respect to that aspect.

2. DESCRIPTION OF RELATED ART

During the fabrication of automobiles, trucks, and similar vehicles, many body components present cavities that require sealing to prevent the ingress of moisture and contaminants that can cause corrosion of the body parts. This is especially true with respect to unibody structures, where a heavy frame is replaced by a structurally designed space frame that inherently presents a number of moisture- and contaminant-collecting cavities. These cavities also serve as passages through which road and engine noise and other sounds may be transmitted during normal use of the vehicle. For example, the upright post structures of a vehicle body defining portions of window openings (the so-called A, B, and C pillars) each present an elongated cavity that can collect moisture and contaminants and also transmit sounds unless the cavity is at least partially filled with a sealant material that blocks the passage of moisture and debris and that also serves as a baffle for muting sounds that would otherwise be transmitted along the length of the cavity and then radiate into the passenger compartment of the vehicle. There are other irregular cavities in a vehicle body that desirably are sealed to prevent moisture and contaminants from entering that area and being conveyed to other parts of the vehicle body.

A currently favored technique in automobile cavity sealing is the use of a heat-activated sealing foam material. Typically, a mass of a material capable of expansion (foaming) at elevated temperatures, i.e. a thermoplastic mixture containing both a heat-activated foaming agent and a heat-activated crosslinking agent, is placed on a bracket or other mechanical support or holder, usually made from sheet metal or a molded high temperature thermoplastic, that is capable of being mechanically fastened within the cavity. Because automobile bodies are now typically coated by total immersion in phosphating, rustproofing, electrocoating, and other paint baths to ensure that the interiors of all open cavities are coated, the sealing article (the support, together with the mass of foamable material), should not fill the cavity cross-section before foaming, so that the coatings may enter the cavity during immersion and drain from it after removal from the bath. As the automobile body is passed through an oven to cure the coating to the metal of the body, the foamable mass expands to fill the cavity cross-section and seal to the walls of the cavity.

While this technique has proved generally satisfactory, it suffers a significant disadvantages in that, because the foam material is not self-supporting during foaming, it is subject to sagging as the material melts and expands and before it crosslinks, and therefore requires support. This problem is particularly severe when the axis of the cavity to be sealed is approximately horizontal, so that the foam material (which is perpendicular to the cavity axis) is approximately vertical, and the sagging therefore tends to limit expansion of the foam toward the upper parts of the cavity walls.

This sagging problem is more acute with formulations of foaming material having low expansion ratios (e.g. a linear expansion ratio of less than 150%) and moderately low viscosity in the melt. Cavity sealing articles made with low expansion material tend to have a greater width of foaming material unsupported by the bracket. While these low viscosity materials have the desirable characteristics of better gap filling capability and better wetting of the cavity wall surfaces, leading to better adhesion, their lower viscosity makes them inherently more susceptible to sagging.

Conversely, if a foamable material with a higher melt viscosity, or one which has been partially crosslinked prior to the expansion step, is used, then the sagging situation maybe somewhat abated, but at the expense of decreased melt flow (poorer gap filling) and wetting. This problem is particularly severe when the cavity to be sealed is highly

irregular in cross-section or has a sharply acute angle, when a considerable excess of foamable material may be used to attempt to ensure that the foam fills the cavity cross-section and penetrates to the vertex of the angle. Thus it is difficult to solve the problem using only a materials formulation approach.

In certain uses, particularly in the sealing of the vertical pillars of automobile bodies, it may be desirable to be able to provide a drain passage within the pillar. For example, in automobiles with sunroofs, it is necessary to provide a drain passage for water which might otherwise accumulate in spaces around the sunroof. Usually, this drain passage is created by a drain tube from the sunroof area passing down one or both of the "A" pillars (the pillars on either side of the front window of the automobile). Thus a passage must be provided through any seal in that pillar. Three different solutions are currently used for this problem. One is to allow the pillar itself to serve as the drain passage and to provide a drainage plug through the cavity seal. The drainage plug has a tortuous path through which fluids may drain, but which is intended to reduce sound travel through the plug. This simple solution has the two disadvantages of allowing draining fluid to contact the inside of the pillar as it drains and of allowing sound infiltration, especially the infiltration of high frequency sound, through the drain plug since the tortuous path is still open. A second solution is to use a conventional seal with a hole, and a drain hose passing through the hole. Here the disadvantages of the drain plug are avoided, but the need for the hose to be emplaced before the vehicle frame is fully assembled means that a hose capable of withstanding the high temperatures encountered in the paint bake ovens must be used, increasing the cost. A third solution is to leave the pillars open through the painting process, then install a low cost hose through the pillar and seal it in place by injection of a foaming material, such as a two-part urethane, into the pillar. This solution also provides an effective seal, but at the increased cost of capital equipment for preparation and injection of the urethane foam, ventilation, etc., and with the need for an additional step in the vehicle assembly process.

Many of the cavities to be sealed a re channels in vehicles, such as the A, B, and C pillars, the rocker channels, etc., of vehicles are constructed of at least two pieces of metal which have been pressed into geometrically complex shapes and mate with each other along a longitudinal flange or flanges. At the vehicle assembly plant, these pieces are typically robotically welded along the flange(s). Prior to assembly and welding of the

flanges, the sealing article is affixed to one of the pieces by a clip, pinch clip, pressure sensitive adhesive, or the like. In many cases, it is common to attach another piece of metal to the already-joined two pieces, and perhaps add another sealing article.

For most applications, the second piece of metal is lowered directly onto the first so that the flanges mate appropriately. However, in some cases, the entry path of the second piece of metal may be constrained by the already-assembled vehicle, or by the need for particular motion of an assembly robotic arm. This requires that the shape of the sealing article be constrained to avoid the entry path; a condition commonly known as an "assembly clearance" requirement. While this assembly clearance can be partially compensated for by the use of a greater quantity of foamable material (a relatively smaller bracket), this increases the risk of the foamable material sagging and failing to seal the cavity.

It would be desirable to produce a cavity sealing article, especially a sealing article for use in a channel in a land, marine, or aerospace vehicle, such as a pillar in the body structure of an automobile or similar vehicle, that could be prepared readily and inexpensively, would be readily handleable and emplaceable within a cavity to be sealed without requiring special tooling, would be readily activatable by elevating the cavity temperature to such temperatures as are commonly encountered in operations on the vehicle body (e.g. 115°C to 250°C for automobile paint ovens), and, on activation, would provide an effective seal against infiltration of air, moisture, other undesirable fluids and particulates, and sound. Desirably, such a sealing article would also permit the passage of drain hoses and the like through the seal.

Some techniques and products for cavity sealing are described in US Patents Nos. 5,931,474 (Chang et al.), 5,631,027 (Takabatake), 5,506,025 (Otto et al.), and 5,213,391 (Takagi); PCT International Publications Nos. WO 99/37506 and WO 98/36944 (Raychem Corporation); and US Patent Applications Nos. 09/285,811 (Williams et al., filed April 1, 1999) and 09/249,248 (Martens et al., filed February 11, 1999). The disclosures of these and other documents referred to throughout this application are incorporated herein by reference.

BRIEF SUMMARY OF THE INVENTION

In a first aspect, this invention provides a planar cavity sealing article comprising:

(a) a planar articulated support, and

(b) a sealer comprising an uncrosslinked foamable polymer in intimate contact with the articulated support and surrounding the articulated support in the plane of the articulated support.

In particular, in this first aspect, this invention provides a planar cavity sealing article for use in a longitudinally extending cavity defined by cavity walls, the cavity having a cross-section within the cavity walls which is to be sealed at a predetermined location, the article comprising:

(a) a planar articulated support, and

(b) a sealer comprising an uncrosslinked foamable polymer in intimate contact with the articulated support and surrounding the articulated support in the plane of the articulated support.

the article having a size and shape such that the article incompletely occupies the cross-section of the cavity at the predetermined location and having expansion and sealing properties such that, when the article is placed at the predetermined location within the cavity and foamed, the foamed sealer comes into intimate and sealing contact with the cavity walls.

Especially, in this first aspect, this invention provides a cavity sealing article for use in a longitudinally extending cavity defined by cavity walls, the cavity having a cross-section within the cavity walls which is to be sealed at a predetermined location, the article comprising:

(a) a planar cavity sealing layer comprising:

(1) a planar articulated support, and

(2) a sealer comprising an uncrosslinked foamable polymer in intimate contact with the articulated support and surrounding the articulated support in the plane of the articulated support; and

(b) a mounting structure adapted to fit within the cavity and orient the article within the cross-section at the predetermined location,

the article having a size and shape such that the article incompletely occupies the cross-section of the cavity at the predetermined location and the sealing layer having expansion and sealing properties such that, when the article is placed at the predetermined location within the cavity and foamed, the foamed sealer comes into intimate and sealing contact with the cavity walls.

In a second aspect, this invention provides a multiple-layer cavity sealing article comprising:

(a) a plurality of planar sealing layers, each sealing layer independently comprising:

(1) a planar articulated support, and

(2) a sealer comprising an uncrosslinked foamable polymer in intimate contact with the articulated support and surrounding the articulated support in the plane of the articulated support; and

(b) a mounting structure orienting the plurality of sealing layers in spaced-apart relationship.

In particular, in this second aspect, this invention provides a multiple-layer cavity sealing article for use in a longitudinally extending cavity defined by cavity walls, the cavity having a cross-section within the cavity walls which is to be sealed at a predetermined location, the article comprising:

(a) a plurality of planar sealing layers, each sealing layer independently comprising:

(1) a planar articulated support, and

(2) a sealer comprising an uncrosslinked foamable polymer in intimate contact with the articulated support and substantially surrounding the articulated support in the plane of the articulated support; and

(b) a mounting structure adapted to fit within the cavity and orient the article within the cross-section at the predetermined location, the mounting structure orienting the plurality of sealing layers in spaced-apart relationship,

the article having a size and shape such that the article incompletely occupies the cross-section of the cavity at the predetermined location and the sealing layers having expansion and sealing properties such that, when the article is placed at the predetermined location within the cavity and foamed, the foamed sealers come into intimate and sealing contact with the cavity walls.

In a third aspect, this invention provides a method of sealing a cavity by use of the cavity sealing article of the invention.

In a fourth aspect, this invention provides a method of making the cavity sealing article of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A, 1B, and 1C are cross-sectional views of a cavity showing a cavity sealing article of the prior art and the problem of assembly clearance.

FIG. 2 is a cross-sectional view of a cavity showing a possible prior-art type solution to the assembly clearance problem.

FIGS. 3A, 3B, and 3C are cross-sectional views of a cavity showing a first embodiment of the cavity sealing article of this invention before, during, and after foaming.

FIG. 4 is a cross-sectional view of a cavity showing a second embodiment of the cavity sealing article of this invention, having a sealer "force reservoir".

FIGS. 5A and 5B are cross-sectional views of a cavity showing a third embodiment of the cavity sealing article of this invention, having three support portions and two hinge portions, before and after foaming.

FIGS. 6A and 6B are cross-sectional views of a cavity showing a fourth embodiment of the cavity sealing article of this invention, having six support portions and five hinge portions, before and after foaming.

FIGS. 7A and 7B are cross-sectional views of a cavity showing a fifth embodiment of the cavity sealing article of this invention, having an aperture therethrough for placement of a drain hose, and its assembly into the cavity.

FIGS. 8A and 8B are cross-sectional views of a cavity showing a sixth embodiment of the cavity sealing article of this invention, where the small support portion is used to direct sealer into a pinch flange, before and after foaming.

FIG. 9 is a perspective view of a planar articulated support of this invention, showing thickened flanges along the facing edges of the support portions to increase the force.

FIG. 10 is a cross-section along lines A-A of FIG. 9, but including the sealer not shown in FIG. 9, to illustrate the thickened flanges.

FIG. 11 is a cross-sectional view of a cavity showing a seventh embodiment of the cavity sealing article of this invention, where the articulated support comprises two support portions joined by a sliding alignment (two pins).

FIGS. 12A and 12B are cross-sections along lines A-A and B-B of FIG. 11.

FIG. 13 is a cross-sectional view of a cavity showing an eighth embodiment of the cavity sealing article of this invention, where the articulated support comprises two support portions joined by a sliding alignment (one pin).

FIG. 14 is a cross-sectional view through a ninth embodiment of the cavity sealing article of this invention, the view being taken parallel to the plane of the articulated support and along the principal direction of expansion of the support, where the articulated support comprises two support portions joined by a sliding alignment (a dovetail).

FIG. 15A is a cross-sectional view through a tenth embodiment of the cavity sealing article of this invention, the view being taken parallel to the plane of the articulated support and perpendicular to the principal direction of expansion of the support, where the articulated support comprises two support portions joined by a sliding alignment (two pins protruding from one of the support portions passing through bores in the other support portion).

FIG. 15B is a cross-section along line B-B of FIG. 15A.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A "support" is the non-foaming portion of a cavity sealing article or sealing layer of this invention that provides support for the foaming sealer portion of the article or layer. The term "support" may also include the means by which the article is firmly emplaced at the desired location within the cavity to be sealed, though this is generally referred to as the "mounting".

An "articulated support" is a support (as defined above) which comprises two or more support portions that are functionally linked together in such a way that each support portion may move independently of the support portion(s) to which it is linked.

The term "planar" is not intended to require strict planarity; but the cavity sealing article and layer of this invention will be generally flat, thin, and elongated in the directions perpendicular to the axis of the cavity within which the article will be emplaced. A planar article of this invention may include protrusions such as pins and sockets mounted one or both sides of the support to achieve articulation of the articulated support, and/or may also include mountings to emplace the article within a cavity to be sealed or other features protruding from the general plane of the article or layer, and the presence of such protrusions, mountings, and the like should not be construed to render the support or article non-planar.

For simplicity and ease of understanding, the invention will be described and illustrated with respect to a cavity sealing article of this invention having only a single sealing layer, where the sealing layer itself forms the cavity sealing article; however, it will be evident to a person of ordinary skill in the art having regard to this disclosure and the documents cited in this application, including specifically, for example, US Patent No. 5,506,025 and PCT Published Application No. WO 98/36944, how to make and use cavity sealing articles having more than one sealing layer.

Referring to the drawings, where like numerals denote like elements of the invention, FIGS. 1A, 1B, and 1C are cross-sectional views of a cavity showing a cavity sealing article of the prior art and the problem of assembly clearance, where the cavity sealing article is emplaced at a predetermined location within a cavity, the longitudinal axis of which is perpendicular to the page. The axis of the cavity may be oriented in any direction: horizontal, oblique, or vertical; so that the cross-section that is to be sealed at the predetermined location may be, correspondingly, vertical, oblique, or horizontal. The cavity shown generally as 10 is defined by a pair of cavity wall forming members 12 and 14 which may be fastened together by any suitable means (not shown). The cavity sealing article shown generally as 20 comprises a single sealing layer of a support 22 surrounded in the plane of the support by and in intimate contact with an uncrosslinked foamable polymer sealer 24. The article 20 is positioned within the cavity 10 by any desired mounting. FIG. 1B shows a possible assembly of the cavity from the two cavity wall forming members 12 and 14, with the arrow indicating the direction of motion of the assembly. FIG. 1C is the same view as FIG. 1A, except that the heavy dashed line indicates the line of motion of the right-hand flange of member 12, illustrating how

assembly clearance requirements would prohibit the use of the cavity sealing article shown (the area above the dashed line would interfere with member 12 during assembly of the cavity with the article inside).

FIG. 2 is a cross-sectional view of a cavity showing a possible prior-art type solution to the assembly clearance problem. Since the top portion of the article must be cut away to provide assembly clearance, and since the sealer has only a limited expansion ratio while the support has none, it is necessary to increase the amount of sealer to obtain the necessary expansion to fill the cavity. This "solution" has the drawback that a significant portion of the sealer is unsupported as it expands, thereby risking sagging and incomplete sealing.

FIGS. 3A, 3B, and 3C are cross-sectional views of a cavity showing a first embodiment of the cavity sealing article of this invention before, during, and after foaming. The article 30 comprises an articulated support 32 having two support portions 34 and 38 joined by a hinge portion 42, and a foamable sealer 44 surrounding the support in the plane of the support. It will be understood that although the article of the invention is shown as a cross-section through the article in the plane of the support in this and other Figures, the sealer in fact comprises a complete layer for the full size of the article on one side of the support, as is shown in FIGS. 10, 12A, 12B, 14, and 15A, and in the documents referred to in the "Description of the Related Art". In FIG. 3A, the sealing article is emplaced within the cavity, but has not yet begun foaming. In FIG. 3B, the article is partly foamed, and the angle between the inner edges 36 and 40 of the two support portions has increased, increasing the size of the wedge-shaped gap between portions 34 and 38. In FIG. 3C, the article is fully foamed to completely fill and seal the cavity, and the angle between the inner edges of the two support portions has further increased, increasing the size of the wedge-shaped gap. The articulated support may be made and hinged in such a way that the support would have an inherent tendency for the angle between the inner edges to open (such as by molding it with a more open angle and then restraining it to a more closed angle while the sealer is added —the sealer then providing the force to hold it in that more closed angle until it softens and foams).

FIG. 4 is a cross-sectional view of a cavity showing a second embodiment of the cavity sealing article of this invention, having a sealer "force reservoir". Here the support portions 34 and 38 each have a cut-out portion, 46 and 48 respectively. These cut-out

portions allow for an increased mass of foamable sealer within the wedge-shaped gap, thereby increasing the force of the expanding sealer available to open the gap. This increased mass of sealer is referred to as a force reservoir.

FIGS. 5A and 5B are cross-sectional views of a cavity showing a third embodiment of the cavity sealing article of this invention, having three support portions and two hinge portions, before and after foaming. Here the articulated support 32 comprises three support portions 34, 38, and 50, rotatably linked by hinge portions 42 and 52; and surrounded in the plane of the support by sealer 44. In FIG. 5A the article is shown before foaming; while in FIG. 5B the article is shown completely foamed. In a case such as this, where support portion 50 moves into the gap between support portions 34 and 38, support portion 38 may be notched so that the free end of support portion 50 engages with the notch as the foaming takes place and the support portions rotate about their hinges, thereby locking the support in an opened position.

FIGS. 6A and 6B are cross-sectional views of a cavity showing a fourth embodiment of the cavity sealing article of this invention, having six support portions and five hinge portions, before and after foaming. Here support portions 54, 56, 58, 60, 62, and 64 are linked by hinge portions 66, 68, 70, 72, and 74. In FIG. 6A the article is shown before foaming; while in FIG. 6B the article is shown completely foamed. A design such as this offer the opportunity to achieve greater expansion of the article, with the sealer supported, than would be possible with a singly hinged support.

FIGS. 7A and 7B are cross-sectional views of a cavity showing a fifth embodiment of the cavity sealing article of this invention, having an aperture therethrough for placement of a drain hose or similar feature, and its assembly into the cavity. Here the article looks somewhat like the article of FIG. 4, except that a portion of the sealer has been cut away, and the cut-out portions of the support portions are lined with sealer, so that the sealer surrounds the support. In FIG. 7A the article is seen "open" and associated with (typically mounted on) member 14, with a drain hose 76 shown in the gap between the two main portions of the article. The arrow shows the direction of motion of the other member 12 in the assembly of the cavity. FIG. 7B shows the article in the assembled cavity, before foaming. As in FIGS. 3A through 3C, the article will foam to fill the cavity, with the drain hose sealed through the article. The ability to manufacture sealing articles of this type, allowing easy assembly and sealing of cavities

with a drain hose or similar feature therein, is a particularly attractive feature of the sealing article of this invention.

FIGS. 8A and 8B are cross-sectional views of a cavity showing a sixth embodiment of the cavity sealing article of this invention, where the small support portion is used to direct sealer into a pinch flange, before and after foaming. Support portions 34 and 38 are hinged by hinged portion 42 so that support portion 38 moves in the direction of the pinch flange in the upper right of the channel 20, thereby helping ensure that sealer 40 is forced into the acute angle. While this aspect of the invention does not in itself aid in assembly clearance issues, it illustrates the advantages of the articulated support in meeting other needs in cavity sealing. As with the embodiment discussed with regard to FIGS. 3A through 3C, the articulated support may be made and hinged in such a way that the support would have an inherent tendency for the angle between the inner edges to open, thereby increasing the force driving the sealer into the acute angles.

FIG. 9 is a perspective view of a planar articulated support of this invention, showing thickened flanges along the facing edges of the support portions to increase the force. Support portions 34 and 38 are joined by hinged portion 42. The inner edges 36 and 40 of the support are provided with flanges 78 and 80 to increase the area against which the expanding sealer acts and thereby increase the opening force exerted by the sealer.

FIG. 10 is a cross-section along lines A-A of FIG. 9, but including the sealer not shown in FIG. 9, to illustrate the thickened flanges. Thus FIG. 10 is a cross-sectional view of a sealing article of this invention similar to that shown in FIGS. 3A through 3C, where the articulated support has thickened flanges. Typical dimensions of the article may be, for an article of total thickness 6 mm, a support thickness of 3 mm (leaving the general thickness of the sealer at 3 mm also), and a thickness for the thickened flanges of 5 mm, leaving a sealer thickness of 1 mm above the flanges and ensuring that the sealer is continuous.

FIG. 11 is a cross-sectional view of a cavity showing a seventh embodiment of the cavity sealing article of this invention, where the articulated support comprises two support portions joined by a sliding alignment (two pins). In FIG. 11, the support portions 34 and 38 are joined by a sliding alignment that comprises two pins 82 and 84 mounted on the surface of support portion 38, while support portion 34 is provided with

two guides 86 and 88 through which the pins can slide to allow relative movement of the two support portions. In this Figure, the support member 34 is shaped to allow for a "force reservoir" of extra sealer, as discussed above with regard to FIG. 4, though this aspect of the embodiment is optional.

FIGS. 12A and 12B are cross-sections along lines A-A and B-B of FIG. 11. In FIG. 12A, the general structure of the sealing article is shown, with the sealer 42 surrounding the support portion 38 in the plane of the support portion. In FIG. 12B, the pins 82 and 84 can be seen passing through the guides 86 and 88.

FIG. 13 is a cross-sectional view of a cavity showing an eighth embodiment of the cavity sealing article of this invention, where the articulated support comprises two support portions joined by a sliding alignment (one pin). It will be apparent that different shapes and orientations of the articulated support and the sealing article are available to achieve sealing of cavities of different shapes and assembly clearance requirements, all within the scope of this invention.

FIG. 14 is a cross-sectional view through a ninth embodiment of the cavity sealing article of this invention, the view being taken parallel to the plane of the articulated support and along the principal direction of expansion of the support, where the articulated support comprises two support portions joined by a sliding alignment (a dovetail). Support portion 34 has at least a part of one edge shaped as a dovetail 90 and support portion 38 has at least a part of one edge shaped as a dovetail recess 92, and the two support portions slide with respect to one another along that dovetail.

FIG. 15A is a cross-sectional view through a tenth embodiment of the cavity sealing article of this invention, the view being taken parallel to the plane of the articulated support and perpendicular to the principal direction of expansion of the support, where the articulated support comprises two support portions joined by a sliding alignment (two pins protruding from one of the support portions passing through bores in the other support portion). This is very similar to the embodiment of FIG. 11 above, except that the pins, rather than being above the plane of the support portion 38 (i.e. on the opposite side of the support from the complete layer of sealer), are run through guides (bores) within the body of the support portion 34.

FIG. 15B is a cross-section along line B-B of FIG. 15A, illustrating the pins 82 and 84 and corresponding bores 86 and 88. A person of ordinary skill in the art will

realize that the shapes of the pin or pins and corresponding guide(s) is not critical, and other sliding alignments such as a tongue sliding in a flat bore may also be appropriate and are within the scope of this invention.

Composition of the sealer

Suitable compositions for the sealer of the cavity sealing article, or for the or a sealing layer of the cavity sealing article, of this invention will be foamable polymer compositions having a foaming temperature appropriate to the temperature range of intended application, for example a foaming temperature within the range of temperatures to be encountered in bake ovens for vehicle bodies, and the like. Such compositions will contain a base polymer and a blowing agent to cause foaming of the polymer. They will typically also contain fillers, antioxidants, flame retardants, and/or other stabilizers such as are conventional in polymeric articles, and may contain pigments, plasticizers, adhesion promoters, activators for the blowing agents, and the like.

The sealer of the article or sealing layer(s) may, and preferably will, contain a chemical crosslinking agent to strengthen the resulting foamed polymer, and may also contain a tackifier to maximize adhesion of the article to the cavity walls on foaming. The sealer is uncrosslinked before foaming, by which is meant that it is either totally free of crosslinking or has such a low degree of crosslinking that it substantially retains the foaming and adhesive characteristics of an uncrosslinked polymer. Desirably, the sealer becomes crosslinked on foaming, as discussed further later in the application, as this provides additional stability to the foam, but it is within the scope of the invention that the sealer may be uncrosslinked (as defined immediately above) even after foaming.

Suitable base polymers may include a wide range of polymers, typically chosen for a particular application so that the resulting article will foam at a convenient temperature for sealing of the cavity to be sealed and will be stable under intended use conditions. A suitable base polymer or mixture of polymers will thus have a softening point below the desired temperature of foaming in the absence of crosslinking, for example at a temperature at least 50°C below the desired foaming temperature. The melt flow index, MFI, as measured by ASTM D-1238-95, of the polymer or mixture of polymers will desirably be from 0.5 to 10, preferably from 3 to 7, and in any event will

desirably be chosen to give an appropriate degree of expansion of the resulting article during foaming.

Suitable polymers thus include olefinic polymers such as very low density polyethylene, low density polyethylene, medium density polyethylene, high density polyethylene, polyethylenes or ethylene copolymers prepared by metallocene polymerization, such as Exact [Exxon] and Engage [Dow], ethylene copolymers such as ethylene-vinyl acetate copolymer, ethylene-methacrylic acid copolymer, ethylene-acrylic acid copolymer, ethylene-butyl acrylate copolymer, ionomers, such as Surlyn [duPont] and Iotek [Exxon], ethylene terpolymers such as ethylene-vinyl acetate-methacrylic acid copolymer, elastomers such as ethylene-propylene rubber, EPDM, nitrile rubbers, butyl rubbers, chloroprene, chloropolyethylene, polyacrylate elastomers, chlorosulfonated polyethylene, thermoplastic elastomers, and fluoropolymers such as polyvinylidene fluoride, ethylene-tetrafluoroethylene copolymer, fluorinated ethylene-propylene copolymer, poly(chlorotrifluoroethylene), ethylene-chlorotrifluoroethylene copolymer, etc., and compatible mixtures of any two or more of the above.

The temperature range at which the sealer is foamed is typically between 115°C and 250°C, such as is found in bake ovens used in the automobile industry. More typically, the temperature range is between 150°C and 180°C, with possible short excursions above 180°C. Typical baking cycles are 10 minutes to 60 minutes, more typically about 30 minutes, in duration.

Thus, for example, a suitable polymer or mixture of polymers for use in a cavity sealing article or sealing layer for use in the automobile industry, may have a softening point below about 100°C, preferably below 90°C, in the absence of crosslinking. Such polymers may include ethylene-vinyl acetate copolymer (EVA), ethylene-methyl acrylate copolymer (EMA), and the like, optionally admixed with each other or with such polymers as low density polyethylene and/or ionomers. An exemplary polymer is EVA having a vinyl acetate (VA) content between 5% and 45%, especially between 15 and 35%, particularly between 20% and 30%.

Suitable fillers for the composition of the sealer include inorganic fillers such as zinc oxide, barium sulfate (Huberbrite), calcium carbonate, magnesium hydroxide, alumina trihydrate, and the like; at a concentration up to about 40 parts per 100 parts of the base polymer.

The blowing agent is chosen so as to effect foaming and expansion of the article or sealing layer(s) at an elevated temperature normally present during the manufacture of the product containing the cavity to be sealed; for example, at a temperature normally present during passage of an automobile body through a paint bake oven. Suitable blowing agents will include from 1 to 15 parts per 100 parts of base polymer of an azodicarbonamide or benzenesulfonyl hydrazide. Suitable azodicarbonamide blowing agents include Celogen® AZ 130 or 3990; and suitable modified azodicarbonamide agents include Celogen® 754 or 765, all from Uniroyal Chemical. Suitable benzenesulfonyl hydrazide blowing agents include p,p'-oxybis(benzenesulfonyl hydrazide), sold as Celogen® OT, and p-toluenesulfonyl hydrazide, sold as Celogen® TSH, both also from Uniroyal. The blowing agent may also be made up of a combination of agents depending on the degree of expansion desired for a particular application; and may also include a blowing agent activator such as diethylene glycol, urea, dinitrosopentamethylenetetramine (DNPT), and the like. Certain fillers, such as zinc oxide (Kadox), may also act as activators for the blowing agent. The amount of activator added will depend on the choice of blowing agent and the amount of expansion required.

Flame retardants may also be present, of such kinds and at such concentrations as will provide flame retardancy for the sealer. These may include halogenated flame retardants such as the polybrominated aromatics (e.g. decabromobiphenyl), and the like, for example in combination with inorganic materials such as antimony trioxide; or may include non-halogenated flame retardants, such as the magnesium hydroxide and alumina trihydrate previously mentioned as fillers.

The chemical crosslinking agent is preferably a free radical crosslinking agent compatible with the base polymer of the sealer. Preferred chemical crosslinking agents are peroxides, such as bis(t-butylperoxy)diisopropylbenzene, 1,1-di-t-butylperoxy-3,3,5-trimethylcyclohexane, 4,4-di-t-butylperoxy n-butyl valerate (Trigonox), dicumyl peroxide (Dicup), and the like. In most cases, the chemical crosslinking agent is provided at 1 to 5 parts per 100 parts of base polymer.

The blowing agent and the chemical crosslinking agent will be chosen so that the chemical crosslinking agent has an activation temperature approximately that of the blowing agent. For example, it may have an activation temperature slightly below that of the blowing agent, so that the foam maintains stability during expansion; but desirably the

kinetics of the crosslinking and foaming reactions are such that the sealer of the article or sealing layer(s) expands and foams on heating, and adheres to the walls of the cavity, before the resulting foam is completely crosslinked by action of the chemical crosslinking agent. Desirably, the activation temperature of the blowing agent will be chosen so that the blowing agent is not easily accidentally activated (such as by mixing at a temperature above the optimal mixing temperature, during welding or other forming of a cavity in which the sealing article is emplaced, or during phosphating, painting or other coating treatments, or drying of such coatings) but is only activated when it encounters temperatures in which it is desired that the sealing article should foam, such as are present in bake ovens.

The tackifier, if present, will be chosen to enhance the tackiness of the outside surface of the sealer, in particular the periphery of the sealer which will come into contact with the cavity walls, on expansion but not such that the outer surface exhibits tackiness after formation of the article and before expansion, since it is generally desirable that the outer surface of the article should be dry and non-tacky during initial placement of the article in the cavity. Desirably, to enhance the adhesive qualities of the base polymer at the temperature of expansion, the tackifier will have a relatively low molecular weight, no significant crystallinity, a ring-and-ball softening point above at least 50°C (and preferably higher, near the softening point of the base polymer), and will be compatible with the base polymer and other polymers present. The tackifier may be present in up to 30 parts per 100 parts of base polymer. Suitable tackifiers include novolak resins, partially polymerized rosins, tall oil rosin esters, low molecular weight aromatic thermoplastic resins, Picco® and Piccotac® resins from Hercules Chemical, and the like.

Antioxidants, adhesion promoters, plasticizers, pigments, and the like may also be employed in conventional amounts.

Exemplary formulations include:

Ingredient	Formulation, parts by weight A	B	C
Elvax 460 (EVA copolymer, du Pont)	74.4		
Ateva 1710 (EVA copolymer, AT Plastics)		78.74	
Elvax 470 (EVA copolymer, du Pont)			71.94
Irganox 1076 (antioxidant, Ciba-Geigy)	0.7	0.79	0.72
Kadox 911 (ZnO, Marman/Keystone)	3.7	3.94	3.60
Piccotac 95 (tackifier, Hercules)	11.2	5.91	10.79
Vulcup 40 KE (peroxide crosslinking agent, Hercules)	3.0	3.15	2.88
Celogen OT-72-DG (blowing agent, Elastochem)	2.5	4.72	7.19
Sartomer SR350 (crosslinking promoter, Sartomer)	3.0	2.36	2.88
Raven C Ultra Beads (carbon black, Columbian Chemical)	1.5	0.39	

Of these formulations, formulation C is of higher viscosity in the melt than formulations A or B.

Suitable other compositions and materials for the sealer include those disclosed in US Patents Nos. 5,931,474 (Chang et al.), 5,677,382 (Tsuji et al.), 5,385,951 (Soderberg), 5,373,027 and 5,266,133 (both to Hanley et al.), 5,091,435 (Suzuki et al.), 4,203,815 (Noda et al.), and 4,166,890 (Fried et al.).

The particular composition used to make the sealer of this invention is not critical; and a person of ordinary skill in the art should have no difficulty, having regard to that skill and this disclosure, including the references cited here, in determining a suitable formulation to prepare a sealer of this invention or in optimizing such a composition for a particular application.

The sealer composition may be prepared by methods conventional in the art of polymer blending, such as by mixing in a high shear mixer such as a Banbury or Brabender type mixer, a sigma blade mixer, or a twin screw extruder, with care being taken to ensure that the temperature of the blend does not rise to such an extent that the chemical crosslinking agent or blowing agent are activated. Typically, the base polymer, other polymers/tackifier (if present), and antioxidant are added first, and blended to homogeneity. The filler, adhesion promoter, and pigments (if present) may be mixed with

the base polymer, or may be added after the base polymer has been softened by mixing. These first mixing stages are not particularly temperature-sensitive. Once all ingredients other than the blowing and crosslinking agents have been added and fully blended, however, temperature control becomes important as these last agents are added. Accordingly, the mixer is cooled so that the temperature of the composition does not exceed about 95°C, and more preferably does not exceed about 80°C; the blowing agent(s), accelerator(s), crosslinking agents, and any plasticizers are added, and the resulting composition is subjected to high shear mixing under controlled temperature conditions until the composition is homogeneous. The composition may then be cooled, for example by processing through a two-roll mill with cooled rollers.

The resulting bulk composition may then be formed into the appropriate shape for the cavity sealing article of this invention by any appropriate means. For example, it may be extruded or rolled into sheets for cutting, extruded into rods of a desired cross-sectional configuration to be subsequently sectioned into the articles, molded into desired shapes, or pelletized for later molding or extrusion.

Composition of the articulated support

The articulated support of the cavity sealing article, or for the or a sealing layer of the cavity sealing article, of this invention may be prepared from any material having the structural integrity and durability necessary to permit storage of the cavity sealing article of this invention, placement of the article within a cavity to be sealed, sealing of the cavity by foaming of the article, and use of the article within the cavity, potentially for an extended time such as the lifetime of a vehicle. This requires both structural stability at elevated temperatures, such as stability at temperatures of at least 150°C, preferably at temperatures of at least 180°C, and the ability to withstand the forces produced by foaming of the article at those temperatures, and long-term durability Typically, the support may be prepared from a high melting point thermoplastic polymer, such as a high temperature polyolefin, a polyamide such as a nylon, for example, nylon 6, nylon 46, or nylon 66, a polyester, such as polyethylene terephthalate, an aromatic polyether, polyether ketone, or polyamide, a thermoset resin, or the like; especially one that may easily be formed into the desired shape. These polymers will typically contain fillers, antioxidants,

flame retardants, and/or other stabilizers such as are conventional in polymeric articles, and may contain pigments, plasticizers, adhesion promoters, and the like. In addition, the polymers may contain reinforcing materials, such as glass fiber and the like, if needed or desired. An exemplary material for the articulated support of this invention is a glass-filled nylon 66, known as Nylon 6/6 520-10G (Ashley Polymers, Inc.). The support may be formed as a single piece, such as by molding, or assembled from two or more pieces.

Manufacture of the cavity sealing article or sealing layer

The thickness of the cavity sealing article or sealing layer of this invention, by which is meant the dimension perpendicular to the plane of the articulated support or layer prior to foaming, will typically be between 3 mm and 13 mm, more typically between 5 mm and 8 mm, especially around 6 mm.

The cavity sealing article or the sealing layer(s) of the cavity sealing article of this invention, as previously described, will typically have a shape and size will be chosen based on the cavity cross-section, the foaming properties of the sealer, and any requirement for assembly clearance, as discussed elsewhere. Subject to that requirement for assembly clearance, the article or layer(s) may have a cross-section that is comparable in shape to the cavity to be sealed, and sized so as to give an appropriate clearance between the emplaced article and the cavity walls.

Also, subject to the requirement for assembly clearance, the width of the sealer may be varied between different portions of the article, depending particularly on the complexity of the shape of the cavity to be sealed. For example, if the cavity is of relatively regular shape and the cavity walls are relatively smooth (lacking in sudden changes in direction), then a relatively greater clearance between the periphery of the article or sealing layer(s) and the cavity walls may be desirable; such as to permit the ready flow of paint when the cavity to be sealed is an automobile pillar painted by total immersion. In such a case, the proportion of the article or layer(s) comprising the support(s) may generally be greater and, correspondingly, the width of the sealer will be less. However, if the cavity is narrow and/or of relatively irregular shape, then a narrower clearance between the periphery of the article or sealing layer(s) and the cavity walls may be desirable to ensure adequate filling of the cavity; and in such a case, the proportion of

the article or layer(s) comprising the support(s) may be smaller and the sealer be of relatively greater width. Thus a cavity of complex shape may be filled by a cavity sealing article of this invention with different clearance gaps between the article or sealing layer(s) and the walls of the cavity and sealer widths at different locations in the article. However, it is a particular feature of the sealing article or layer of this invention that it is the articulation of the support that permits the sealing article or layer to size itself on expansion so as to fill the cavity to be sealed so that unusually large sealer widths (which may permit sagging) are not needed.

Typically, subject to assembly clearance, the article or sealing layer(s) will be sized not directly as a proportion of the dimensions of the cavity at the predetermined location that is to be sealed, but by considering a certain clearance between the article or layer(s) and the cavity walls at the predetermined location, for example from 1 mm to about 8 mm, for example, about 3 mm to 5 mm, depending on the size of the cavity and the complexity of the cavity shape, and then calculating from the desired clearance and the resulting size of the article the extent of expansion that will be required to seal the cavity, taking into account the desirability of the support when expanded by the expansion of the sealer substantially filling the cavity at the desired location with the sealer providing primarily the sealing between the article or layer(s) and the cavity walls. Because the shape and articulation of the support and the extent of expansion of the sealer may conveniently be varied, it will be possible to optimize the size and properties of the article or layer(s) to fill the cavity.

Typically, a multiple-layer cavity sealing article of this invention will have two sealing layers, but this invention also contemplates articles having more than two sealing layers. For simplicity, and because the invention and its manufacture and use is adequately described by an article having only two layers, the drawings illustrate the invention only with reference to two-layer cavity sealing articles; however, a person of ordinary skill in the art will have no difficulty, having regard to that skill and this disclosure, in manufacturing and using a multiple-layer cavity sealing article having more than two layers.

While it is possible that all of the sealing layers of a particular multiple-layer cavity sealing article may be the same, it is also possible that not all of the sealing layers must be the same.

The use of a cavity sealing article in which each sealing layer is the same offers advantages in manufacture, both because only one type of sealing layer is required to be manufactured and because the assembly of the multiple-layer cavity sealing article is simplified when only one type of sealing layer is used — the sealing layer parts of the article are identical and no choice among different parts is required.

However, there may be circumstances in which the use of sealing layers that are not all the same may offer advantages in the multiple-layer cavity-sealing article of this invention. One example is where the cross-section of the cavity to be sealed changes substantially at the predetermined location, such as where the cavity changes in cross-sectional area, where the cavity changes in cross-sectional shape but not in area, or where the cavity curves or is otherwise irregular at the predetermined location. In each of these circumstances, it will be apparent to a person of ordinary skill in the art that it may be desirable that the sealing layers be of different sizes and/or shapes even if they are otherwise identical in composition and thickness, so that each sealing layer may be chosen to best seal the cross-section of the cavity at the point where it is placed. Even if the cross-section of the cavity to be sealed is the same for each sealing layer of a multiple-layer cavity sealing article, it still may be desirable that the sizes, compositions, thicknesses, or degrees of expansion of the various sealing layers not all be the same. For example, it is highly desirable that at least one (and preferably all) of the sealing layers of the article completely seal the cross-section of the cavity at the point where it is placed. If only one sealing layer is used, then, that layer is chosen to ensure complete sealing, and this certainty of sealing (achieved by choice of the driver and sealer size, degree of expansion, etc.) may not in itself be optimal in other properties, such as acoustic properties. In particular, it may require that the sealing layer have a hardness that is greater or less than desirable for maximum acoustic benefit. In the multiple-layer article of this invention, it is possible to have different sealing layers optimized for different functions within the sealing article. For example, one sealing layer may be optimized to ensure complete sealing of the cavity cross-section while another sealing layer may be optimized to provide a more efficient acoustic barrier, etc. Similarly, the sealing layers may be of different thicknesses, if desired. A person of ordinary skill in the art, having regard to that knowledge and this disclosure, will be able to determine suitable sealing

layers for a multiple-layer sealing article of this invention and to optimize them for a particular application.

Preferred methods of manufacture of the article are those methods where the articulated support is initially prepared (either as a single piece or as multiple pieces fastened together), and the sealer then applied to the support. Such methods include injection molding, insert molding, and extrusion coating. A particularly convenient method for those articles where the support is made as a single piece, i.e. where the articulation of the support is provided by hinge portions of the same material as the support portions, is to prepare the support by molding and then mold the sealer around the support by insert molding, which offers the dual advantages of efficiency in manufacture and improved adhesion of the sealer to the support (because the support is still at elevated temperature when the sealer is molded around it).

A person of ordinary skill in the art will be able, having regard to that skill and this disclosure, to select suitable materials and perform a suitable method of manufacture for a cavity sealing article or sealing layer(s) of a sealing article of this invention.

The mounting structure

If the cavity sealing article of this invention comprises a mounting structure, that support structure performs two functions: first, it is adapted to fit within the cavity to be sealed and orient the article or sealing layer(s) within the cross-section of the cavity at the predetermined location; and second, in the case of a multiple-layer sealing article, it supports the sealing layers in spaced-apart relationship.

The support structure or components may be prepared from any material having the structural integrity and durability necessary to permit storage of the cavity sealing article of this invention, placement of the article within a cavity to be sealed, sealing of the cavity by foaming of the article, and use of the article within the cavity, potentially for an extended time such as the lifetime of a vehicle. This requires both structural stability at elevated temperatures, such as stability at temperatures of at least 150°C, preferably at temperatures of at least 180°C, and the ability to withstand the forces produced by foaming of the article at those temperatures, and long-term durability Typically, the mounting structure may be prepared from the same material as use in the support, and

may even be co-molded therewith if that is convenient. The mounting structure may be formed as a single piece, such as by molding, or assembled from two or more pieces.

The shape of the mounting structure is designed so that it fits within the cavity to orient the article within the cross-section of the cavity at the predetermined location, desirably so that the sealing layer(s) lie perpendicular to the cavity walls, and the mounting structure will therefore be provided with features that are capable of interaction with the cavity walls to provide that orientation, as is discussed further below.

In addition, the shape of the mounting structure for a multiple-layer cavity sealing article is designed so that it supports the plurality of sealing layers in spaced-apart relationship. Thus, for each sealing layer, the mounting structure will provide a support for that layer so that it is appropriately oriented within the cavity and so that a sealed space is formed within the cavity between each two sealing layers when the sealing layers of the article have been foamed and expanded. Typically, the mounting structure will support the plurality of sealing layers in parallel spaced-apart relationship; but if the cavity is of irregular shape or is to be sealed at a curve, etc., it may be desirable for the sealing layers to be non-parallel so that each sealing layer separately lies perpendicular to the cavity walls, for example.

Thus, the support structure may be of the kind well-known in the art for other foamable cavity seals and as discussed in the documents referred to in the "Description of Related Art"; and a person of ordinary skill in the art should have no difficulty, having regard to that skill and this disclosure (including the referenced documents) in designing an appropriate mounting structure for a sealing article of this invention.

The spacing between the or each pair of sealing layers in a multiple-layer article may be chosen to maximize the attenuation at a desired frequency, achieved by spacing the sealing layers approximately $\lambda/4$ apart, where λ is the wavelength of the sound at the desired frequency. Because the sealing layers are not themselves completely rigid, this idealized $\lambda/4$ spacing may not in fact be optimal, and some adjustment of the spacing may be appropriate to achieve the attenuation profile most desired. Such adjustments are within the ordinary skill of the art.

Manufacture of the mounted cavity sealing article

The mounted cavity sealing article is manufactured by mounting the or each of the sealing layers on the mounting structure. Depending on the design of the article, this may be accomplished by mounting the or each sealing layer on the structure by means of one or more studs, screws, or relatively small supports. The sealing layers may also be provided with holes to engage protrusions, clips, or the like, formed in the mounting structure; or the mounting structure may be provided with adhesive surfaces by which the sealing layers may be fastened to it.

It will be evident to one of ordinary skill in the art, having regard to that skill and this disclosure that a variety of means may be used to emplace the sealing article of this invention within a cavity to be sealed, and that all such means fall within the scope of this invention.

Use of the cavity sealing article

The cavity sealing article of this invention is used by placement in the cavity to be sealed, subject to assembly clearance requirements, preferably approximately centrally in the cavity cross-section and with the cross-section of the article approximately coincident with the cross-section of the cavity. The article may be emplaced in the cavity by such means as are conventional in the art, for example by emplacement through a hole into an already formed cavity or, more usually, by fastening onto one of two or more members which are subsequently fastened together to form the cavity. In some instances, the cavity to be sealed will have a structural part or parts which will support the cavity sealing article in a desired location, particularly if the article has been molded or shaped to a predetermined shape for that location and/or is provided with molded-in features (for example, holes or protrusions) to engage those parts. In other instances, the article may be formed with features, such as protrusions extending from the periphery of the article in the plane of the articulated support, such that the protrusions engage the cavity to provide correct placement of the article in the predetermined location. The article may also be provided with clips or the like, about which it has been molded, to engage holes in the cavity walls; or may be provided with holes to engage protrusions, clips, or the like,

formed in or attached to the cavity walls. The article may also be emplaced by fastening to a mounting structure, which is in turn fastened to or otherwise firmly located in the cavity, such as is well-known in the art for other foamable cavity seals.

To permit the passage of drain hoses, electrical wiring, or the like objects through the cavity sealing article of this invention subsequent to the installation and foaming of the article, the cavity sealing article may be provided with one or more apertures through the article or, in a particularly attractive feature of the articulated support articles of this invention, may also have the whole article articulated such that the article may be emplaced around the hose or wiring rather than the hose or wiring needing to be threaded through an aperture. FIGS. 7A and 7B illustrate this feature.

It will be apparent that embodiments of the cavity sealing article having multiple sealing layers may be provided with an aperture or apertures therethrough, such as those shown and described previously with regard to embodiments having a single sealing layer; and all such variations are considered as being within the scope of this invention.

When the article is emplaced within a cavity of a vehicle, the article is desirably placed such that there is substantially complete clearance around it within the cavity before activation and foaming, thereby permitting the phosphating, rustproofing, electrochemical painting, and other treatments such as are commonly given to vehicle bodies. When the article is emplaced within a cavity that is not subject to painting and the like, such clearance is not necessary.

When it is desired to activate and foam the sealing article of this invention, the article is exposed to a sufficient temperature for a sufficient time to activate the blowing agent and the chemical crosslinking agent. Suitable times and temperatures will depend on the application in which the seal is to be used, and may include temperatures between 100°C and 300°C or greater for periods between 5 and 100 minutes. Typically, in the case of sealing channels in new vehicle bodies, this heat activation will occur when the body is placed in a paint bake oven to cure previously applied paint, and such temperatures and times are typically between 115°C and 250°C for 10 to 60 minutes, for example 160°C for 30 minutes, but a person of ordinary skill in the art will realize that other temperatures and times may be appropriate. Also, the sealing article may be activated by other heat sources (for example, local heating such as induction heating of the area), for example if it is being used for repair purposes or is being emplaced in a

large structure. On heating, the support articulates and the uncrosslinked sealer of the article softens and foams into intimate sealing contact with the walls of the cavity. The foam of the sealer then chemically crosslinks, stabilizing the sealer foam so that the foamed article forms a stable plug filling the whole cross-section of the cavity and intimately bonded to the cavity walls, acting as a moisture, sound, and particulate barrier.

This invention may be practiced in combination with the invention disclosed in US Patent Application No. 09/249,248, referred to previously, in which a secondary sealer having a melt viscosity lower than that of the foamable sealer is used to seal acutely angled corners (such as at "pinch flanges") that may be present in a cavity; and any such combination is included within the scope of this application.

While the preceding detailed description of the preferred embodiments includes passages that are chiefly or exclusively concerned with particular features or aspects of the invention. It is to be understood that this is for clarity and convenience, that a particular feature may be relevant to the invention in more than just the passage in which it is disclosed, and that the disclosure of this application includes all appropriate combinations of information found in the different passages. Similarly, it is to be understood that where a specific feature is disclosed in the context of a particular feature or embodiment, such a feature may also be used, to the extent appropriate, in the context of another figure or embodiment, in combination with another feature, or in the invention in general.

Finally, while this invention has been described in conjunction with specific preferred embodiments, the invention is not limited to such preferred embodiments but only to the following claims. It will be evident to one of ordinary skill in the art, having regard to this disclosure, that equivalents of the specifically disclosed materials and techniques will also be applicable to this invention; and such equivalents are included within the following claims.

CLAIMS

1. A planar cavity sealing article comprising:

(a) a planar articulated support, and

(b) a sealer comprising an uncrosslinked foamable polymer in intimate contact with the articulated support and surrounding the articulated support in the plane of the articulated support.

2. A planar cavity sealing article for use in a longitudinally extending cavity defined by cavity walls, the cavity having a cross-section within the cavity walls which is to be sealed at a predetermined location, the article comprising:

(a) a planar articulated support, and

(b) a sealer comprising an uncrosslinked foamable polymer in intimate contact with the articulated support and surrounding the articulated support in the plane of the articulated support.

the article having a size and shape such that the article incompletely occupies the cross-section of the cavity at the predetermined location and having expansion and sealing properties such that, when the article is placed at the predetermined location within the cavity and foamed, the foamed sealer comes into intimate and sealing contact with the cavity walls.

3. A cavity sealing article for use in a longitudinally extending cavity defined by cavity walls, the cavity having a cross-section within the cavity walls which is to be sealed at a predetermined location, the article comprising:

(a) a planar cavity sealing layer comprising:

(1) a planar articulated support, and

(2) a sealer comprising an uncrosslinked foamable polymer in intimate contact with the articulated support and surrounding the articulated support in the plane of the articulated support; and

(b) a mounting structure adapted to fit within the cavity and orient the article within the cross-section at the predetermined location,

the article having a size and shape such that the article incompletely occupies the cross-section of the cavity at the predetermined location and the sealing layer having expansion and sealing properties such that, when the article is placed at the predetermined location within the cavity and foamed, the foamed sealer comes into intimate and sealing contact with the cavity walls.

4. A multiple-layer cavity sealing article comprising:

(a) a plurality of planar sealing layers, each sealing layer independently comprising:

(1) a planar articulated support, and

(2) a sealer comprising an uncrosslinked foamable polymer in intimate contact with the articulated support and surrounding the articulated support in the plane of the articulated support; and

(b) a mounting structure orienting the plurality of sealing layers in spaced-apart relationship.

5. A multiple-layer cavity sealing article for use in a longitudinally extending cavity defined by cavity walls, the cavity having a cross-section within the cavity walls which is to be sealed at a predetermined location, the article comprising:

(a) a plurality of planar sealing layers, each sealing layer independently comprising:

(1) a planar articulated support, and

(2) a sealer comprising an uncrosslinked foamable polymer in intimate contact with the articulated support and substantially surrounding the articulated support in the plane of the articulated support; and

(b) a mounting structure adapted to fit within the cavity and orient the article within the cross-section at the predetermined location, the mounting structure orienting the plurality of sealing layers in spaced-apart relationship,

the article having a size and shape such that the article incompletely occupies the cross-section of the cavity at the predetermined location and the sealing layers having expansion and sealing properties such that, when the article is placed at the predetermined location within the cavity and foamed, the foamed sealers come into intimate and sealing contact with the cavity walls.

6. The article of Claim 4 which comprises two sealing layers.

7. The article of Claim 6 where each sealing layer is the same.

8. The article of Claims 1 or 4 where the article or the or a sealing layer of the article has a thickness between 3 mm and 13 mm.

9. The article of Claim 8 where the article or the or a sealing layer of the article has a thickness between 5 mm and 8 mm.

10. The article of Claims 1 or 4 having at least one aperture therethrough.

11. The article of Claims 1 or 4 where the or a planar articulated support comprises at least two support portions each joined by a hinge portion to at least one other of the support portions such that, on foaming, the support portions of the articulated support pivot with respect to one another about the or each hinge portion.

12. The article of Claim 11 where the or a planar articulated support has two support portions.

13. The article of Claim 11 where the or a planar articulated support has more than two support portions.

14. The article of Claims 1 or 4 where the or a planar articulated support comprises at least two support portions each joined by at least one sliding alignment to at least one other support portion such that, on foaming, the support portions of the articulated support move with respect to one another along the sliding alignment.

15. The article of Claim 14 where the or a planar articulated support comprises two support portions.

16. The article of Claim 14 where the or a sliding alignment comprises at least one pin protruding from a first support portion in a desired principal direction of expansion of the articulated support and a socket in a second support portion slidably mounted on that at least one pin.

17. The article of Claim 16 where the or a sliding alignment comprises two pins.

18. A method of sealing a longitudinally extending cavity defined by cavity walls, the cavity having a cross-section within the cavity walls which is to be sealed at a predetermined location, the method comprising:

(a) providing a planar cavity sealing article according to any one of Claims 1, 2, 4, and 5;

(b) placing the article within the cross-section of the cavity at the predetermined location; and

(c) heating the article for a sufficient time and to a sufficient temperature that the article or the or each sealing layer foams to form an expanded foam barrier in the cross-section of the cavity and seals to the cavity walls.

19. The method of Claim 18 where the cavity is a cavity within a unibody frame of an automobile, and the step of heating comprises baking the frame of the automobile in a paint bake oven.

20. A method of preparing a planar cavity sealing article or a sealing layer for a cavity sealing article comprising a planar articulated support and a sealer comprising an uncrosslinked foamable polymer in intimate contact with the articulated support and surrounding the articulated support in the plane of the articulated support or layer, the method comprising:

(a) providing a planar articulated support; and

(b) molding an uncrosslinked foamable polymer around that support in the plane of the articulated support or layer to form the sealer.

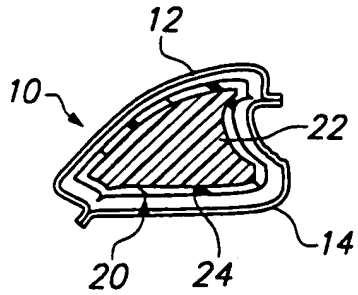

FIG. 1A

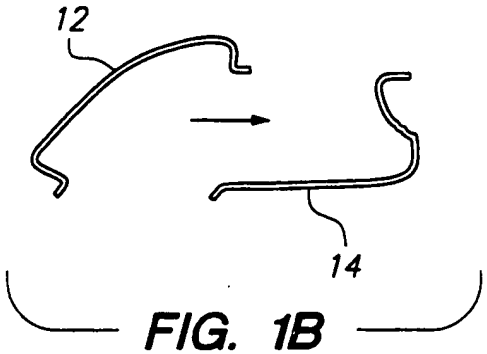

FIG. 1B

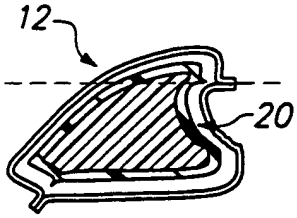

FIG. 1C

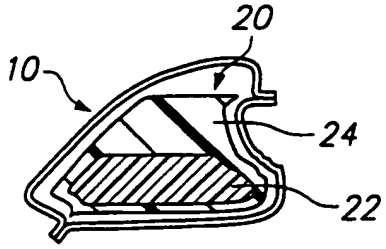

FIG. 2

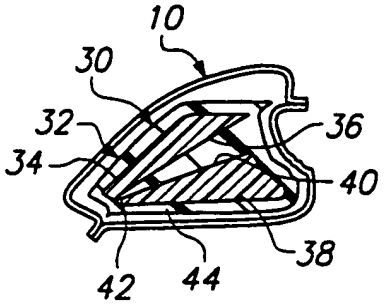

FIG. 3A

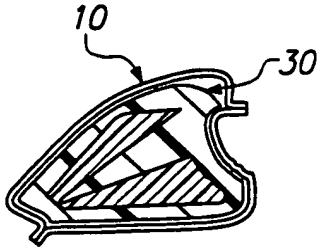

FIG. 3B

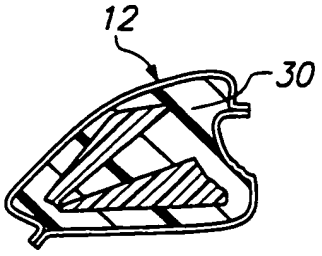

FIG. 3C

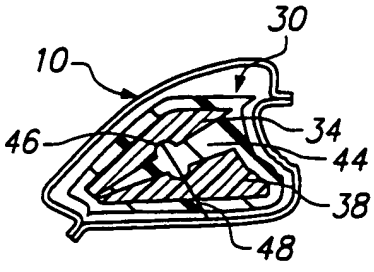

FIG. 4

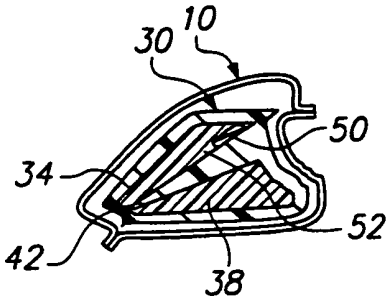

FIG. 5A

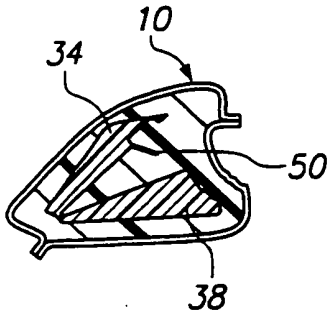

FIG. 5B

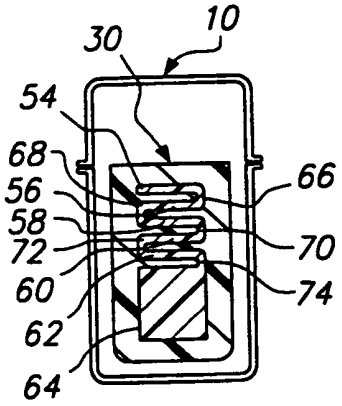

FIG. 6A

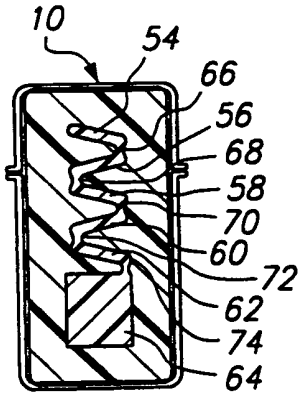

FIG. 6B

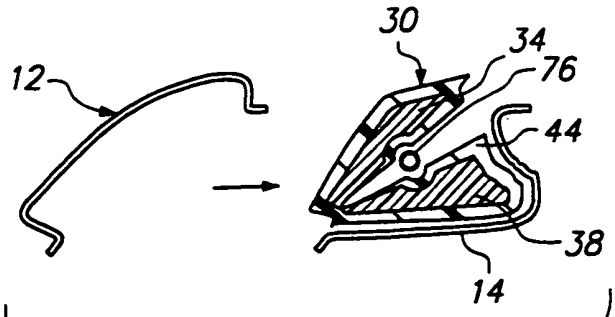

FIG. 7A

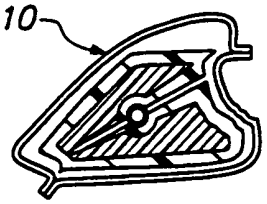

FIG. 7B

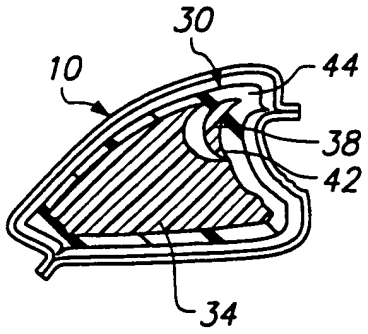

FIG. 8A

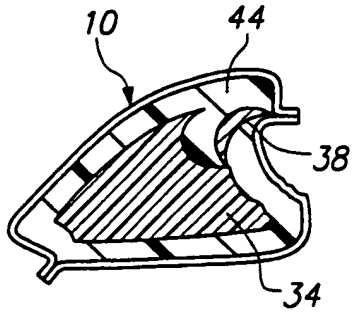

FIG. 8B

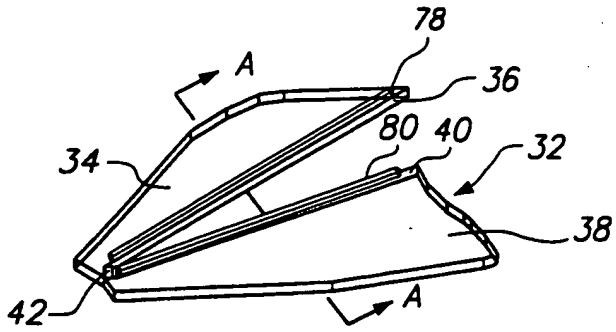

FIG. 9

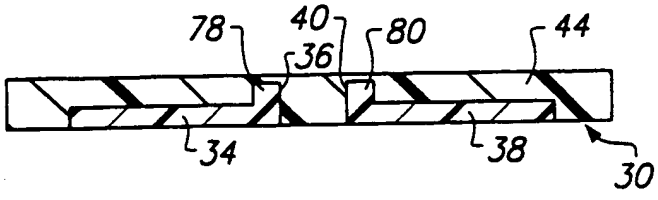

FIG. 10

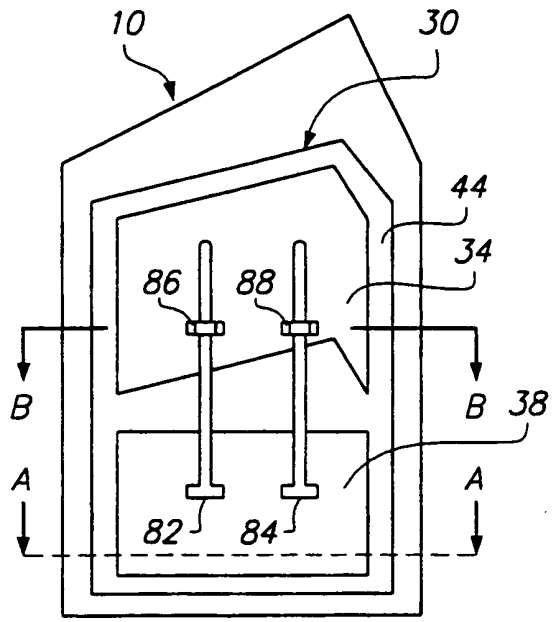

FIG. 11

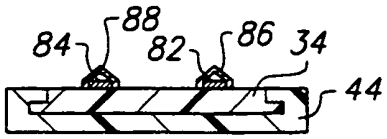

FIG. 12B

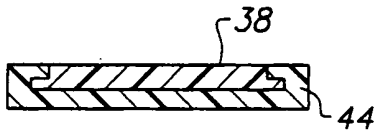

FIG. 12A

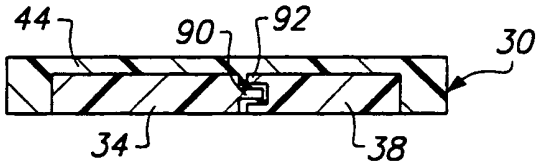

FIG. 14

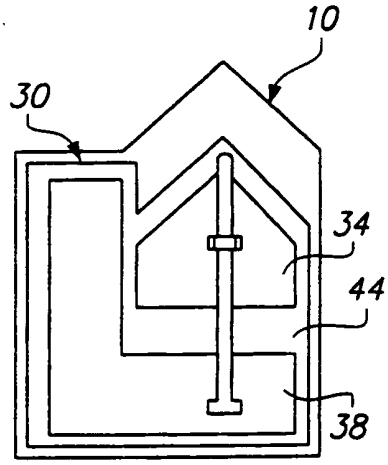

FIG. 13

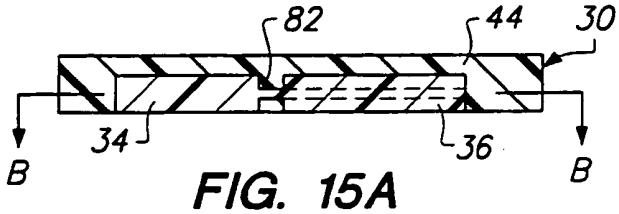

FIG. 15A

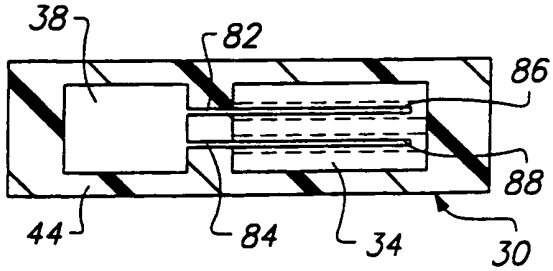

FIG. 15B

INTERNATIONAL SEARCH REPORT

Intern .al Application No
PCT/US 00/26834

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B29C44/18 B60R13/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B29C B60R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 834 962 A (STRUMBOS W) 10 September 1974 (1974-09-10) column 4, line 45 -column 5, line 58 column 7, line 62 - line 63; figures ---	1-15, 18-20
X	DE 38 38 655 A (BAYERISCHE MOTOREN WERKE AG ;CIBA GEIGY GMBH (DE)) 17 May 1990 (1990-05-17) column 2, line 49 -column 3, line 6; figures ---	1-3,11, 13,18-20
A	US 5 631 027 A (TAKABATAKE YOSHIHIRO) 20 May 1997 (1997-05-20) cited in the application figures --- -/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 December 2000	02/01/2001

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

Intern al Application No
PCT/US 00/26834

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 889 012 A (DAIMLER BENZ AG) 7 January 1999 (1999-01-07) figure 2	
A	EP 0 730 999 A (NEO EX LAB INC) 11 September 1996 (1996-09-11)	

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

Intern al Application No
PCT/US 00/26834

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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